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(71) Applicant *(for all designated States except US)*: THE UNIVERSITY OF SHEFFIELD [GB/GB]: Western Bank, Sheffield S10 2UH (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: AGGARWAL, Varinder, Kumar [GB/GB]; The University of Sheffield, Dept. of Chemistry, Dainton Building, Sheffield S2 7HF (GB).

(74) Agent: RUTTER, Keith; SmithKline Beecham, Corporate Intellectual Property, SB House, Great West Road, Brentford, Middlesex TW8 9BD (GB).

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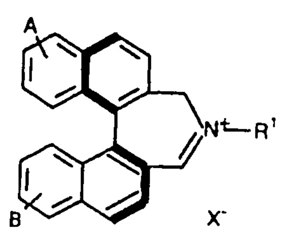
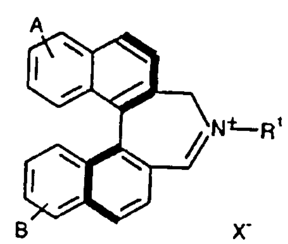
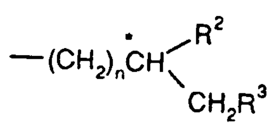


(Ia)



(Ib)



(a)

(57) Abstract

A compound of formula (Ia) or (Ib), wherein A and B each independently represents hydrogen or one, two or three naphthylidene substituents, which substituents are selected from C_{1-6} alkyl, C_{1-6} alkoxy, aryl, aryloxy, silyl and silyloxy; R^1 represents phenyl, C_{1-6} alkyl, phenyl C_{1-6} alkyl or a moiety of formula (a): wherein R^2 represents C_{1-6} alkyl, phenyl or benzyl, R^3 represents H or OR^4 wherein R^4 is C_{1-6} alkyl or C_{1-6} alkylsilyl and n is zero or an integer 1 or 2; and X is a counter ion; a process for the preparation of such compounds and the use of such compounds for enantioselectively epoxidising a prochiral olefin.

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DINAPHTAZEPINIUM SALTS USEFUL AS ENANTIOSELECTIVE EPOXIDATION CATALYSTS

This invention relates to novel compounds and the use of such compounds as catalysts in oxygen transfer reactions.

The catalytic asymmetric epoxidation of alkenes using chiral catalysts, in particular the salen manganese complexes of Jacobsen et al (International Patent Application, Publication Number WO/91/14694), is now well established methodology in asymmetric synthesis. The importance of these catalytic systems stems in the main from the versatility of application of the asymmetric epoxidation reaction itself. This versatility is due to the many and varied nucleophiles which can be used to open the substrate epoxide providing a concomitantly varied range of enantiomerically enriched products which are increasingly required for use for the manufacture of biologically important compounds such as pesticides, herbicides and pharmaceuticals.

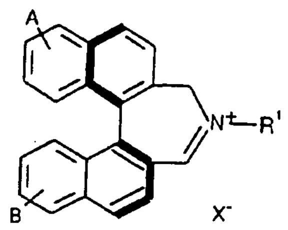
In addition to organo-transition metal based catalysts, such as the Jacobsen catalysts purely organic asymmetric catalysts are also known. Thus Hanquet *et al* (Tetrahedron Letters, Vol. 34, no.45, pp7271-7274) have demonstrated that the oxaziridinium salt (1S, 2R, 3R, 4S)-N-methyl-1,2-oxido-3-methyl-4-phenyl-1,2,3,4-tetrahyroisoquinolinium tetrafluoroborate catalyses the asymmetric epoxidation of *trans*-stilbene and the asymmetric oxidation of methyl p-tolyl sulphide to the corresponding sulphoxide. The oxaziridinium salts are prepared *in situ* from a catalytic amount of an iminium salt and oxone (Hanquet *et al* C.R.Acad Sci., Paris, 1991, 313,SII, pp625-628).

Unlike the salen manganese complexes and other organo-transition metal based catalysts, the oxaziridinium catalysts do not function by means of radical intermediates. They may therefore be used with a wider range of alkene substrates as there is no requirement for π-stabilising groups on the alkene (to stabilise incipient radicals). Also, the oxidation reactions of the oxaziridinium catalysts are stereospecific in the sense that cis alkenes give cis epoxides and trans alkenes give trans epoxides. To date however, despite these advantages, the oxaziridinium catalysts have not provided oxidation systems for use on an industrial scale.

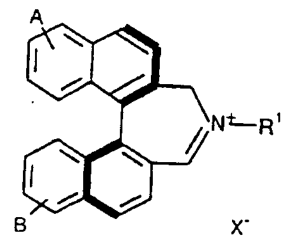
It has now been discovered that a novel series of oxaziridium salts show much promise in the catalytic asymmetric epoxidation of alkenes. The catalytic

reaction employed is simple and robust enabling the use of readily available and cheap reagents as well as environmentally safe solvents.

Accordingly, in a first aspect, the invention provides a compound of formula (Ia) or (Ib):



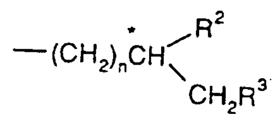
(Ia)



(Ib)

wherein A and B each independently represents hydrogen or one, two or three naphthylidene substituents, which substituents are selected from C_{1-6} alkyl, C_{1-6} alkoxy, aryl, aryloxy, silyl and silyloxy;

R^1 represents phenyl, C_{1-6} alkyl, phenyl C_{1-6} alkyl or a moiety of formula (a):



wherein R^2 represents C_{1-6} alkyl, phenyl or benzyl, R^3 represents H or OR^4 wherein R^4 is C_{1-6} alkyl or C_{1-6} alkylsilyl and n is zero or an integer 1 or 2; and

X is a counter ion.

Suitably, A represents hydrogen.

Suitably, B represents hydrogen.

Examples of R^1 when it represents C_{1-6} alkyl are methyl and ethyl groups.

An example of R_1 is benzyl.

Suitably, R^2 represents C_{1-6} alkyl.

Suitably, R^3 represents C_{1-6} alkyl.

Preferably, R^1 represents C_{1-6} alkyl,

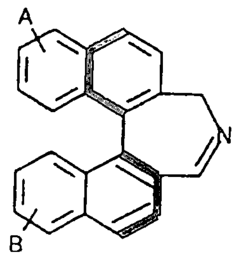
Values for the counter ion X^- include BF_4^-, Cl^-, Br^-, I^-, ClO_4^- and PF_6^-.

A preferred value for the counter ion X^- is BF_4^-.

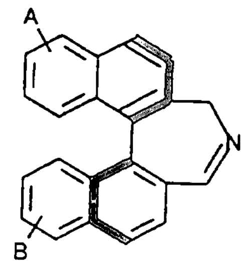
A suitable aryl group is a phenyl group.

As used herein, alkyl groups, whether present alone or as part of other groups such as alkoxy or aralkyl groups, are alkyl groups having straight or branched carbon chains, containing 1 to 6 carbon atoms, e.g. methyl, ethyl, n-propyl, iso-propyl, n-butyl, isobutyl or tert-butyl groups.

The compounds of formula (Ia) and (Ib) may be prepared by reacting, as appropriate, a compound of formula (IIa) or (IIb):



(IIa)



(IIb)

wherein A and B are as defined in relation to formula (I), with an alkylating agent of formula (III):

$$R^1\text{-}L^1 \qquad \text{(III)}$$

wherein R^1 is as defined in relation to formula (I) and L^1 is a leaving group or atom; and thereafter salting the compound produced with a source of counter ion X^-.

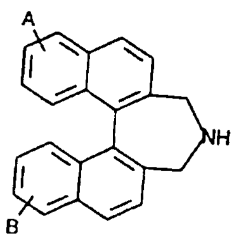
L^1 usually represents halide, such as bromide or iodide, tosyl. or mesyl.

The reaction between the compounds of formulae (II) and (III) may be carried out with or without a solvent; when using a solvent it is suitably an organic solvent, generally an inert organic solvent such as methylene dichloride, at a low to elevated temperature such as a temperature in the range of from 0 to 100°C, conveniently at ambient temperature; preferably the reaction is carried out under anhydrous conditions; preferably the reaction is carried out in an inert atmosphere, for example under nitrogen.

The salting reaction with the source of counter ion X^- may be carried out using any conventional procedure but is usually effected in the solvent used in the reaction, at ambient temperature.

The source of counter ion X^- may be any conventional source such as an appropriate metal salt and especially a silver salt, conveniently however alkylating agent (III) is also the source of counter ion X^-; for example when preparing compounds of formula (Ia) or (Ib) wherein R^1 is C_{1-6} alkyl and X^- is BF_4^-,the compound of formula (II) is a compond $(R^{1a})_3OBF_4$, wherein R^{1a} is C_{1-6} alkyl, especially methyl.

The compounds of formula (IIa) and (IIb) may be prepared by oxidation of a chiral amine of formula (IV):



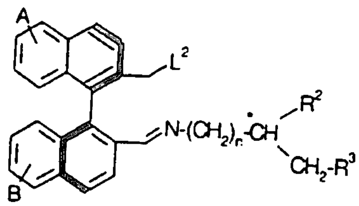
wherein A and B are as defined in relation to fórmula (I), suitably using potassium permanganate as oxidant in the method of Fleischhacker *et al*, monatsh chem. 1989 120 765. (IV)

The chiral compounds of formula (IV) may be prepared from the racemic compound of formula (IV) using conventional resolution methods, for example, the method disclosed by Hawkins and Fu in Journal of Organic Chemistry 1986, 51, 2820-2822.

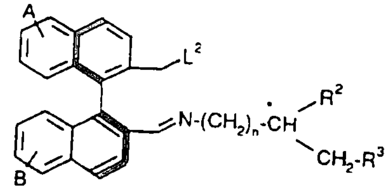
The compounds of formula (III) are known compounds or they may be prepared using methods analogous to those used to prepare known compounds, for example the methods disclosed by W. S. Johnson *et al*, Journal of American Chemical Society, 1963, 85, 1409.

The compounds of formula (IV) are known compound or they are prepared using methods analogous to those used to prepare known compounds, for example the methods disclosed by Hawkins and Fu *ibidem*.

The compounds of formula (Ia) and (Ib) wherein R^1 represents a moiety of the above defined formula (a), may be prepared, as appropiate, by cyclising a compound of formula (Va) or (Vb):



(Va)



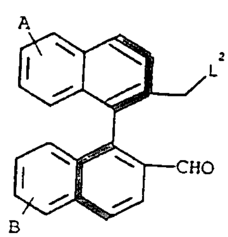
(Vb)

wherein A, B, R^2, R^3 and n are as defined in relation to formula (I) and L^2 represents a leaving group; and thereafter salting the compound produced with a source of counter ion X^-.

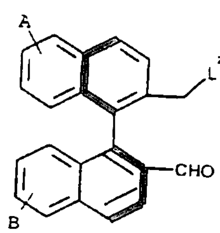
The cyclisation reaction of the compounds of formula (Va) and (Vb) may be carried out in an suitable organic solvent, usually an aprotic solvent such as acetone, at ambient or an elevated temperature, conveniently at the reflux temperature of the solvent.

The salting reaction with the source of counter ion X^- may be carried out using any conventional procedure but is usually effected in the solvent used in the cyclisation reaction, at ambient temperature. The source of counter ion X^- may be any conventional source such as an appropriate metal salt, for example when X^- is BF_4^- a suitable source is an alkali metal borotetrafluoride, such as sodium tetrafluoroborate or silver tetrafluoroborate.

The compounds of formula (Va) and (Vb) may be prepared by reacting, as appropriate, a compound of formula (VIa) or (VIb):

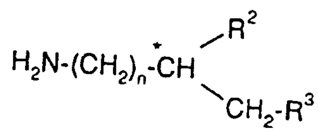


(VIa)



(VIb)

wherein A, B and L^2 are as defined in relation to formula (Va), with a compound of formula (VII):



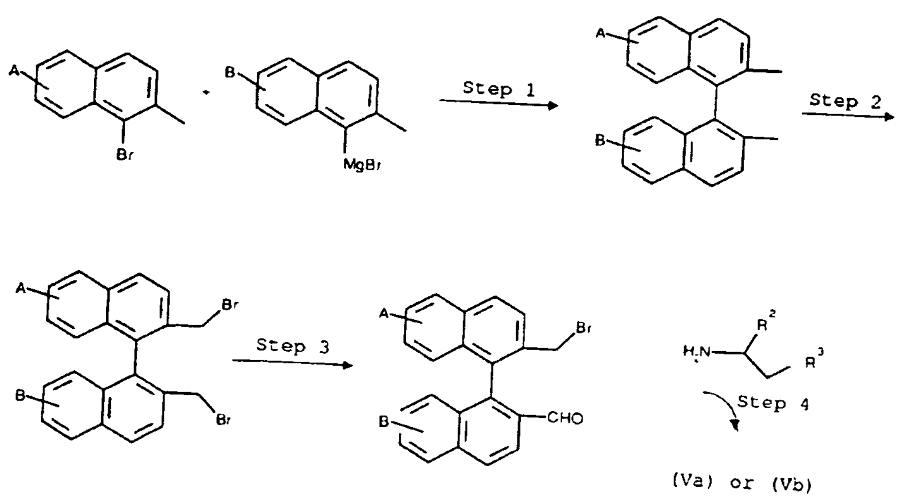
(VII)

wherein R^2, R^3 and n are as defined in relation to formula (I).

The reaction between the compound of formula (VIa) or (VIb) and the compound of formula (VII) may be carried out using any suitable organic solvent, generally an aprotic solvent such as tetrahydrofuran, usually at a low or medium elevated temperature such as a temperature in the range of from -78 to 50°C.

The compounds of formula (VII) are known compound or they may be prepared using methods analogous to those used to prepare known compounds, for example the methods disclosed by Evans *et al*, Organic Synthesis, Vol. 68, 1989, 77

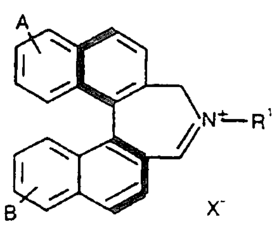
The compounds of formula (VIa) and (VIb) may be prepared in accordance with methods illustrated below:



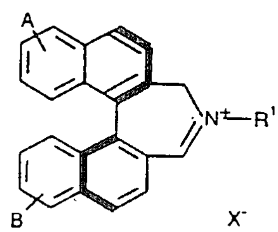
wherein A and B are as defined in relation to formula (I), the conditions of reaction and reagents used in for Steps 1 to 4 being those found in the following references:

Steps 1 and 2: N. Naigrot, J.P. Mazaleyrat, Synthesis, 1985, p 317.
Step 3: H. B. Hass, M.L.Bender, Org, Syn.,Coll. Vol. 4, 1963, 932.
Step 4: B. Bezas, L. Zervas, JACS, 1961, 83, 719.

As stated above the compounds of formula (I) are useful catalysts in the asymmetric epoxidation of alkenes. Accordingly, in a further aspect the invention provides a process for enantioselectively epoxidising a prochiral olefin such as 1-phenylcyclohexene, 1-methylcyclohexene, trans-stilbene and methylstilbene, which process comprises reacting the prochiral olefin with a nucleophilic oxidising agent in the presence of a catalyst, characterised in that the catalyst is a compound of formula (Ia) or (Ib):



(Ia)



(Ib)

wherein A and B each independently represents hydrogen or one, two or three naphthylidene substituents, which substituents are selected from C_{1-6} alkyl, C_{1-6} alkoxy, aryl, aryloxy, silyl and silyloxy;

R^1 represents phenyl, C_{1-6} alkyl, phenyl C_{1-6} alkyl or a moiety of formula (a):

$$-(CH_2)_n\overset{*}{C}H\begin{matrix} R^2 \\ CH_2R^3 \end{matrix}$$

wherein R^2 represents C_{1-6} alkyl, phenyl or benzyl;

R^3 represents H or OR^4 wherein R^4 is C_{1-6} alkyl or C_{1-6} alkylsilyl and n is zero or an integer 1 or 2; and

X is a counter ion.

One suitable nucleophilic oxidising agent is provided by a mixture of oxone ($KHSO_5$) and $NaHCO_3$.

The epoxidation reaction may be carried out using any suitable procedure wherein the prochiral olefin, the nucleophilic oxidising agent and the compound of formula (Ia) or (Ib) are allowed to react thereby providing the required epoxide.

The reaction is carried out in an organic solvent such as acetonitrile, dimethysulphoxide, dimethylformamide or pyrdine or in an organic solvent/water mixture such as aqueous acetonitrile.

Aqueous acetonitrile is a particularly apt reaction solvent when oxone/$NaHCO_3$ is the nucleophilic oxidising agent.

The reaction is carried out at a low to medium-elevated temperature such as a temperature in the range of from -20 to 50°C, preferably at ambient temperature.

Suitably, the reaction is carried out at a neutral or alkaline pH such as in the range of from pH 7 to 14, preferably it is carried out in the range of from pH 8 to 10.

Suitably the molar ratio of the compound of formula (Ia) or (Ib) to the prochiral olefin is in the range of from 1 to 20mol %, preferably in the range of from 5 to 10 mol %.

The following preparation and examples illustrate the present invention.

Iminium Salt Catalysts

General Preparation Procedure:

To a solution of the required imine in CH_2Cl_2 was added the corresponding alkylating agent. The reaction was left to react at room temperature until completion. The solvent was then removed and the residue was precipitated out in ether to give the desired salt.

Example 1: (S-(+)-5,5-Dihydro-2H-dinaphth[2,1-c:1',2'-e]-N-methyl azepine Tetrafluoroborate

To a solution of (S)-imine from Preparation 1 (400mg, 1.36 mmol) in dry CH_2Cl_2 (10 ml) was added under N_2, Me_3OBF_4 (222mg, 1.5 mmol) in one portion. The reaction was left to react at room temperature under N_2 for 24h. The solvent was removed and the residue was precipitated out in ether to give the desired salt (518 mg, 96%), $[\alpha]_D^{20}$+ 1070 (c 1.1 in CH_2Cl_2); δ_H (250 MHz; $CDCl_3$) 4.05 (3H, s, CH_3), 4.6 (1 H, d, J 12.5 Hz, ArCH'H), 4.95 (1 H, d, J 12.5Hz, ArCHH'), 7.0-8.25 (12 H, m, Ar-H), and 9.2 (1 H, s, CH=N); δ_C (62 MHz; $CDCl_3$) 48.76, 58.8, 125.29, 126.14, 126.78, 126.9, 127.12, 127.21, 127.5, 128.68, 129.54, 129.67, 130.12, 130.89, 131.41, 131.78, 131.93, 133.87, 135.29, 141.12, and 168.36; m/z (FAB) 308 (M^+-87, 100%) (Found 308.1448. $C_{23}H_{18}N$ requires 308.1439).

Example 2: (*S*)-(+)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-methyl azepine iodide

A solution of (S)-imine from Preparation 1 (50 mg, 0.17 mmol) in iodomethane (2 ml) was stirred at room temperature, and very soon a yellow solid was formed in the reaction mixture. TLC of the reaction after 24 h showed only a small amount of starting material left. The remaining imine and excess of iodomethane were removed trituration with ether. After drying under high vacuum the desired compound was obtained as a yellow solid (72 mg, 97%); δ_H (250 MHz; $CDCl_3$) 4.25 (3 H, s, CH_3), 4.70 (1 H, d, *J* 13.1 Hz, ArC*H*'H), 4.85 (1 H, d, *J* 13.1 Hz, ArC*H*H'), 7.00-8.50 (12 H, m, Ar-H), and 10.50 (1 H, s, N=CH).

Example 3: (*S*)-(+)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-methyl azepine perchlorate

A solution of $AgClO_4$ (34.3 mg, 0.17 mmol) in acetone (1 ml) was added to a solution of (S)-iminium salt from Example 2 (72 mg, 0.16 mmol) in CH_2Cl_2 (1 ml). The solid formed was filtered off and the filtrate was concentrated to give

the desired iminium salt which was precipitated from ether. After drying under high vacuum the desired compound was obtained as a yellow solid (60 mg, 90%), $[\alpha]D^{20}$ + 769 (c 1.09 in acetone); δ_H (250 MHz; $CDCl_3$) 4.15 (3 H, s, CH_3), 4.70 (1 H, d, *J* 13 Hz, ArC*H*H'), 4.80 (1 H, d, *J* 13 Hz, ArC*H*H'), 7.0-8.2 (12 H, m, Ar-H), and 9.35 (1 H, s, N=CH); δ_C (100 MHz; d_6-acetone) 49.44, 59.19, 126.59, 126.64, 127.62, 127.85, 127.93, 128.03, 128.46, 129.58, 129.60, 130.01, 130.24, 130.26, 130.91, 131.76, 132.18, 132.40, 132.82, 134.83, 136.92, 141.86, and 169.98.

Example 4: (*R*)-(-)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-methyl azepine hexfluorophosphate

A solution of $AgPF_6$ (40.7 mg, 0.16 mmol) in acetone (1 ml) was added to a solution of (R)-iminium salt from Example 2 (70 mg, 0.16 mmol) in CH_2Cl_2 (2 ml). The solid formed was filtered off and the filtrate was concentrated to give the desired iminium salt which was precipitated from ether. After drying under high vacuum the desired compound was obtained as a yellow solid (65 mg, 92%), $[\alpha]D^{20}$-778 (c 1.25 in acetone); δ_H (250 MHz; $CDCl_3$) 4.09 (3 H, s, CH_3), 4.64 (1 H, d, *J* 13 Hz, ArC*H*H'), 4.89 (1 H, d, *J* 13 Hz, ArC*H*H'), 7.00-8.25 (12 H, m, Ar-H), and 9.12 (1 H, s, N=CH); δ_C (100 MHz; CD_2Cl_2) 49.22, 59.60, 125.17, 125.95, 126.67, 127.42, 127.52, 127.82, 128.18, 129.02, 129.07, 129.96, 130.24,, 130.97, 131.42, 131.94, 32.37, 132.44, 134.37, 135.02, 135.92, 142.19, and 168.56.

Example 5: (*S*)-(+)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-ethyl azepine Iodide

A solution of (S)-imine from Preparation 1 (50 mg, 0.17 mmol) in iodoethane (2 ml) was stirred at room temperature, a yellow solid was soon formed in the reaction mixture. TLC of the reaction after 24 h showed that only a small amount of starting material was left. The remaining imine and excess iodoethane were removed by trituration with ether. After drying under high vacuum the desired product was obtained as a yellow solid (60 mg, 98%), m.p. >200 °C (dec.), $[\alpha]D^{20}$ + 878 (c 0.41 in CH_2Cl_2); δ_H (250 MHz; $CDCl_3$) 1.51 (3 H, t, *J* 7 Hz, CH_3), 4.45-4.75 (2 H, m, CH_2CH_3), 4.6 (1 H, d, *J*, 12.5 Hz, ArC*H*H'), 4.95 (1 H, d, *J* 12.5 Hz, ArC*H*H'), 7.00-8.60 (12 H, m, Ar-H), and 10.60 (1 H, s, N=CH); δ_C (100 MHz; CD_2Cl_2) 14.30, 57.75, 57.86, 125.21, 127.09, 127.42, 127.62, 127.68, 127.89, 128.93, 129.04, 129.75, 129.84, 130.62, 131.72, 131.93, 132.04, 132.45, 134.23, 135.41, 135.80, 141.95, and 168.23; m/z (FAB) 323 (M^+-128), 322 (M^+-129, 100%), and 308 (M^+-141) ; HRMS: m/z calc. 322.1604. $C_{24}H_{20}N$ (M^+-127) found 322.1596.

Example 6: (*R*)-(-)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-ethyl azepine Tetrafluoroborate

A solution of $AgBF_4$ (40 mg, 0.2 mmol) in acetone (1 ml) was added to a solution of the (R)-iminium salt from Example 5 (76 mg, 0.17 mmol) in CH_2Cl_2 (2 ml). The solid (AgI) formed was removed by filtration. The resulting foam, obtained by concentration of the filtrate, was triturated with ether to gave the desired product as a yellow gum (59 mg, 84%); $[\alpha]_D^{20}$ - 832 (c 0.87 in acetone); δ_H (250 MHz; CD_2Cl_2) 1.50 (3 H, t, *J* 6.5 Hz, CH_3), 4.25 (2 H, q, *J* 6.5 Hz, CH_2CH_3), 4.53 (1 H, d, *J* 13Hz, ArC*H*'H), 4.94 (1 H, d, *J* 13 Hz, ArC*H*H'), 6.9-8.15 (12 H, m, Ar-H), and 9.13 (1 H, s, N=CH); δ_C (100 MHz; CD_2Cl_2) 13.87, 57.49, 58.38, 125.46, 126.33, 126.88, 127.02, 127.10, 127.15, 127.86, 128.86, 128.97, 129.67, 129.97, 130.64, 131.60, 131.87, 132.01, 132.40, 134.25, 135.82, 141.86, and 167.90

Example 7: (*S*)-(+)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-benzyl azepine Bromide

A solution of (S)-imine from Preparation 1 (50 mg, 0.17 mmol) in benzyl bromide (2 ml) was left to stir at room temperature for 2 days. TLC of the reaction showed a small amount of starting material left. Excess benzyl bromide was removed under vacuum and the residue was triturated with ether to remove the unreacted starting material and trace amounts of benzyl bromide. After drying under high vacuum the desired compound was obtained as a yellow solid (75 mg, 95%), m.p. 150-152 °C (dec.), $[\alpha]_D^{20}$ + 450 (c 1.48 in CH_2Cl_2); δ_H (250 MHz; $CDCl_3$) 4.45 (1 H, d, *J* 13.4 Hz, ArC*H*'H), 4.90 (1 H, d, *J* 13.4 Hz, ArC*H*H'), 5.80 (1 H, d, *J*, 13.0 Hz, PhC*H*'H), 5.94 (1 H, d, *J* 13.0 Hz, PhC*H*H'), 6.75-8.6 (17 H, m, Ar-H), and 11.22 (1 H, s, N=CH); δ_C (100 MHz; $CDCl_3$) 56.55, 65.28, 124.68, 126.86, 126.94, 127.19, 127.44, 128.47, 128.65, 128.74, 128.97, 129.35, 129.49, 129.87, 130.19, 130.90, 131.03, 131.45, 131.60, 133.44, 135.34, 141.42, and 169.45; m/z (FAB) 385 (M^+-79), 384 (M^+-80, 100%); HRMS: m/z calc. 384.1745 $C_{29}H_{22}N$ (M^+-80) requires 384.1752.

Example 8: (*R*)-(-)-5,5-Dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-benzyl azepine Tetrafluoroborate

To a solution of (R)-bromide salt from Example 7 (prepared from 50 mg, 0.17 mmol of (R)-imine from Preparation 1) in CH_2Cl_2 (2 ml) was added $AgBF_4$ (40 mg, 0.2 mmol). The solid (AgBr) formed was separated and the filtrate

concentrated. The resulting foam was triturated with ether to gave the desired product as a yellow gum (48 mg, 60%); $[\alpha]_D^{20}$ - 637 (c 0.6 in acetone); δ_H (250 MHz; $CDCl_3$) 4.55 (1 H, d, *J* 12.5 Hz, ArC*H*'H), 4.95 (1 H, d, *J* 12.5 Hz, ArC*H*H'), 5.48 (1 H, d, *J* 14 Hz, PhC*H*'H), 5.58 (1 H, d, *J* 13 Hz, PhC*H*H'), 6.65-8.16 (17 H, m, Ar-H), and 9.55 (1 H, s, N=CH); δ_C (100 MHz; $CDCl_3$) 56.54, 66.12, 124.71, 126.60, 126.63, 126.92, 127.14, 127.51, 128.50, 128.66, 129.43, 129.47, 129.70, 130.01, 130.18, 130.29, 130.64, 130.95, 131.05, 131.45, 131.60, 133.46, 135.41, 135.44, 141.56, and 168.17.

Catalytic Epoxidation using Iminium Salt Catalysts

General Procedure

To a solution of alkene (0.5 mmol) in a mixture of acetonitrile (4.5 ml) and water (1-2 drops) were added first finely crushed $NaHCO_3$ (2 mmol) and oxone (0.5 mmol) then the catalyst (0.05 mmol or 0.025 mmol). The resulting yellow suspension was allowed to react at room temperature, under good stirring. The reaction was monitored using thin layer chromatography (TLC). Usually towards the end of the reaction the colour of the mixture changed from bright yellow to nearly colourless. Water was added to the reaction mixture followed by extraction into methylene dichloride. The organic extracts were combined and dried over anhydrous sodium sulphate. Concentration on a rotary evaporator gave a material which was purified (column chromatography) to give the desired epoxide.

Example 1: Preparation of Phenyl cyclohexene oxide

To a solution of phenyl cyclohexene (79mg, 0.5 mmol) in a mixture of acetonitrile (4.5 ml) and water (2 drops) were added first finely crushed $NaHCO_3$ (168 mg, 2mmol) and oxone (307 mg, 0.5 mmol) then the catalyst (0.05 mmol). The resulting yellow suspension was allowed to react at RT, under good stirring. TLC was used to follow the reaction which indicated that the reaction was finished in 2 h . Water (3 ml) was added to the reaction mixture followed by extraction into methylene dichloride. The organic extracts were combined and dried over anhydrous sodium sulphate. Concentration on a rotary evaporator gave a material which was purified on a column using 2% ethyl acetate : petrol

mixture as eluent to give the desired compound as a colourless oil. (72mg, 83% yield, 70% e.e).

The epoxidation of phenyl cyclohexene to phenyl cyclohexene oxide was then carried out using other catalysts of the invention. The results obtained are shown in Table 1

Table 1

Example No.	R^1	X	Yield %	ee %
1	Me	BF_4	83	70
3	Me	ClO_4	54	74
4	Me	PF_6	48	61
5	Et	I	55	78
6	Et	BF_4	78	76
7	Bn	Br	71	74
8	Bn	BF_4	78	73

Preparation 1: (R(-) and S(+) 5,5-Dihydro-2H-dinaphth[2,1-c:1',2'-e]azepine

To a solution of (R)- or (S)-amine (295 mg, 1 mmol) (Journal of Organic Chemistry, 1986, 51, 2820-2822) in THF (5ml) was added $KMnO_4$(648 mg, 4 mmol). The reaction was allowed to react at room temperature for 5 h before the solid was removed by filtration. Concentration of the filtrate followed by purification on column using ethyl acetate : petrol (1:1) as eluant gave the desired compound as a syrup (234 mg, 80%),

(S)- isomer, $[\alpha]_D^{20}$+1363.7, (c 1.19 in CH_2Cl_2);

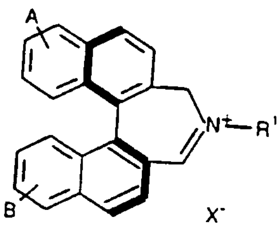
(R)- isomer, $[\alpha]_D^{20}$-1363.7, (c 1.19 in CH_2Cl_2);

Both isomers: δ_H (250 MHz; $CDCl_3$) 3.95 (1 H, dd, J 2.2 Hz and 11 Hz, ArC<u>H</u>H'), 4.96 (1 H, d, J 11 Hz, ArC<u>H</u>H'), 7.0-8.1 (12 H, m, Ar-H), and 8.6 (1 H, d, J 2.2 Hz, CH=N); δ_C (62 MHz; $CDCl_3$) 55.90, 124.36, 125.27, 125.87, 126.05, 126.42, 126.69, 127.16, 127.49, 128.07, 128.25, 128.44, 129.18, 130.49,

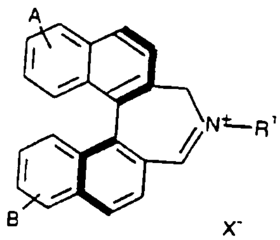
131.70, 132.08, 132.34, 132.99, 135.04, 136.99, 140.96, and 162.47; m/z (FAB) 294 (M^{+}+1, 100%), 154 (M^{+}-139), and 136 (M^{+}-157) (Found 294.1275.$C_{22}H_{16}N$ requires 294.1283).

Claims:

1. A compound of formula (Ia) or (Ib):



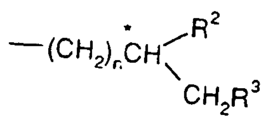
(Ia)



(Ib)

wherein A and B each independently represents hydrogen or one, two or three naphthylidene substituents, which substituents are selected from C_{1-6} alkyl, C_{1-6} alkoxy, aryl, aryloxy, silyl and silyloxy;

R^1 represents phenyl, C_{1-6} alkyl, phenyl C_{1-6} alkyl or a moiety of formula (a):



wherein R^2 represents C_{1-6} alkyl, phenyl or benzyl, R^3 represents H or OR^4 wherein R^4 is C_{1-6} alkyl or C_{1-6} alkylsilyl and n is zero or an integer 1 or 2; and

X is a counter ion.

2. A compound according to claim 1, wherein A represents hydrogen and B represents hydrogen.

3. A compound according to claim 1 or claim 2, wherein R^1 represents C_{1-6} alkyl

4. A compound according to any one of claims 1 to 3, wherein R^1 represents C_{1-6} alkyl.

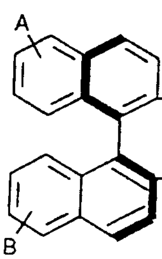
5. A compound according to any one of claims 1 to 4, wherein R^1 represents methyl or ethyl.

6. A compound according to any one of claims 1 to 5, wherein counter ion X^- is selected from the list consisting of: BF_4^-, Cl^-, Br^-, I^-, ClO_4^- and PF_6^-.

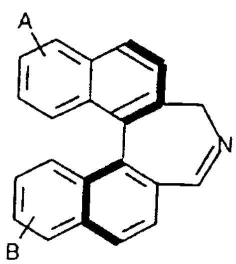
7. A compound according to any one of claims 1 to 6, wherein counter ion X^- is BF_4^-.

8. A compound according to claim 1, selected from the list consisting of:
(S-(+)-5,5-dihydro-2H-dinaphth[2,1-c:1',2'-e]-N-methyl azepine tetrafluoroborate;
(*S*)-(+)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-methyl azepine iodide;
(*S*)-(+)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-methyl azepine perchlorate;
(*R*)-(-)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-methyl azepine hexfluorophosphate;
(*S*)-(+)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-ethyl azepine iodide;
(*R*)-(-)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-ethyl azepine tetrafluoroborate;
(*S*)-(+)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-benzyl azepine bromide; and
(*R*)-(-)-5,5-dihydro-2*H*-dinaphth[2,1-*c*:1',2'-*e*]-N-benzyl azepine tetrafluoroborate.

9. A process for the preparation of the compounds of formula (Ia) and (Ib) which process comprises reacting, as appropriate, a compound of formula (IIa) or (IIb):



(IIa)



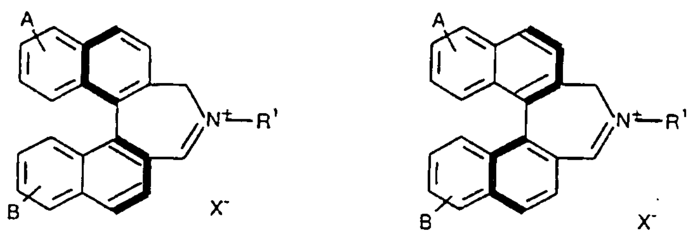
(IIb)

wherein A and B are as defined in relation to formula (I), with an alkylating agent of formula (III):

$$R^1\text{-}L^1 \qquad \text{(III)}$$

wherein R^1 is as defined in relation to formula (I) and L^1 is a leaving group or atom; and thereafter salting the compound produced with a source of counter ion X^-.

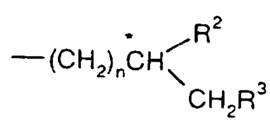
10. A process for enantioselectively epoxidising a prochiral olefin which process comprises reacting the prochiral olefin with a nucleophilic oxidising agent in the presence of a catalyst, characterised in that the catalyst is a compound of formula (Ia) or (Ib):



(Ia) (Ib)

wherein A and B each independently represents hydrogen or one, two or three naphthylidene substituents, which substituents are selected from C_{1-6} alkyl, C_{1-6} alkoxy, aryl, aryloxy, silyl and silyloxy;

R^1 represents phenyl, C_{1-6} alkyl, phenyl C_{1-6} alkyl or a moiety of formula (a):



wherein R^2 represents C_{1-6} alkyl, phenyl or benzyl;

R^3 represents H or OR^4 wherein R^4 is C_{1-6} alkyl or C_{1-6} alkylsilyl and n is zero or an integer 1 or 2; and

X is a counter ion.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 96/03551

A. CLASSIFICATION OF SUBJECT MATTER
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B. FIELDS SEARCHED

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	TETRAHEDRON LETTERS, vol. 34, no. 45, 1993, OXFORD GB, pages 7271-4, XP002020018 L. BOHÊ ET AL.: "The stereospecific synthesis of a new chiral oxaziridinium salt" cited in the application see the whole document ---	1-10
Y	TETRAHEDRON LETTERS, vol. 24, no. 12, 1983, OXFORD GB, pages 1243-6, XP002020019 J.P. MAZALEYRAT: "Méthode simple de synthèse d'agents de transfert chiraux par action d'un agent alkylant à squelette binaphtyle-1,1'" see the whole document ---	1-10
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[X] Further documents are listed in the continuation of box C.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
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PCT/EP 96/03551

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 360 568 A (S.A. MADISON ET AL.) 1 November 1994 see the whole document ---	1-10
P,X	CHEMICAL COMMUNICATIONS, no. 2, January 1996, CAMBRIDGE GB, pages 191-2, XP002020020 V. K. AGGARWAL ET AL.: "Catalytic asymmetric synthesis of epoxides mediated by chiral iminium salts" see the whole document -----	1-10

1

INTERNATIONAL SEARCH REPORT

tion on patent family members

Inter nal A on No
PCT/EP 96/03551

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-5360568	01-11-94	AU-A-	8060994	29-05-95
		WO-A-	9513352	18-05-95
		EP-A-	0728182	28-08-96
		US-A-	5482515	09-01-96
		US-A-	5550256	27-08-96
		ZA-A-	9408978	13-05-96

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(71) Applicant (*for AU BB CA GB GH IE IL KE LC LK LS MN MW NZ SD SG SL SZ TT UG ZW only*): UNILEVER PLC [GB/GB]; Unilever House, Blackfriars, London EC4P 4BQ (GB).

(71) Applicant (*for all designated States except AU BB CA GB GH IE IL KE LC LK LS MN MW NZ SD SG SL SZ TT UG US ZW*): UNILEVER N.V. [NL/NL]; Weena 455, NL-3013 AL Rotterdam (NL).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): THOMPSON, Katherine, Mary [GB/GB]; 19 Ambleside Close, Thingwall, Wirral, Merseyside L61 3XG (GB). THORNTHWAITE, David, William [GB/GB]; Lorien, 23 Leighton Road, Neston, South Wirral, Cheshire L64 3SF (GB).

(74) Agent: ELLIOTT, Peter, William; Unilever plc, Patent Division, Colworth House, Sharnbrook, Bedford MK44 1LQ (GB).

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(54) Title: IMPROVEMENTS RELATING TO BLEACHING COMPOSITIONS COMPRISING HYDROGEN PEROXIDE

(57) Abstract

The invention provides a bleaching composition of pH 10–14 which comprises an oxygen transfer agent and hydrogen peroxide. It is believed that the reaction of hydrogen peroxide with the imine quat. oxygen transfer agents proceeds through a different route than that of the organic and inorganic peroxides. As a consequence, the formation of acyl hydroxamate is significantly reduced. Furthermore it is believed that when hydrogen peroxide is used as the bleaching agent in the pH range indicated, a surprising improvement in the efficacy of the bleaching system occurs and it is possible to formulate peroxide based systems which have efficacy approaching or exceeding that of hypochlorite without the disadvantages associated with hypochlorite. A further aspect of the present invention provides a method for bleaching a stained substrate which comprises the step of treating the substrate with a bleaching composition of pH 10–14, which bleaching composition comprises an oxygen transfer agent and hydrogen peroxide.

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IMPROVEMENTS RELATING TO BLEACHING COMPOSITIONS COMPRISING HYDROGEN PEROXIDE

Field of the Invention

The present invention relates to bleaching compositions comprising hydrogen peroxide.

Background to the Invention

In household cleaning, fabric washing and in many other areas there is a general need for agents which can 'bleach' unsightly materials, i.e. which can react with these materials to decolourise them. One of the commonest of such bleaching agents is sodium hypochlorite, which is widely used in cleaning compositions to decolourise soils, to assist in cleaning through its reaction with soils and to kill micro-organisms.

Sodium hypochlorite is a powerful oxidising agent, which can decolourise a very large number of coloured compounds found in soils but which has significant limitations when used to bleach certain fatty and pyrolised soils. Many consumers prefer not to use chlorine-based bleach compounds due the characteristic and pungent smell of chlorine. In some circumstances the use of a chlorine containing bleaching composition must be avoided due to the possibly adverse effects of mixing such compositions with acidic bathroom cleaners and the resulting release of chlorine gas.

There is a need for an alternative to chlorine-based bleaching and bleaching/cleaning agents. One well known class of alternatives are the peroxygen compounds. While these have been used extensively as bleaching and cleaning agents, the efficacy of peroxygen compounds as bleaching agents falls short of that of hypochlorite. There is therefore a general need to find new alternatives to chlorine based bleaching agents and to improve the properties of these towards that of hypochlorite.

It is known to use oxygen transfer agents such as 'imine quat' compounds to promote the bleaching activity of peroxygen compounds. In the context of the present invention, an oxygen transfer agent is a species which reacts with a peroxygen compound such as hydrogen peroxide to form an oxidative bleaching species which oxidative bleaching species, subsequently reacts with a substrate to regenerate the oxygen transfer agent.

Such oxygen transfer agents include N-methyl-3.4-dihydroisoquinolinium salts. US 5360569 discloses that imine quat molecules can be used to promote the activity of TAED/perborate bleaching compositions. These systems are believed to work by generating per-acetic acid in situ. This organic peroxide is believed to interact with the imine quat. to bring about the bleaching activity. US 5360568 discloses that imine quat molecules can be used to promote the activity of monopersulphate (an inorganic peroxygen compound) and peroxy-adipyl-phthalimide (PAP) (an the organic peracid).

In the above-mentioned compositions the imine quat is believed to be converted, by reaction with the peracid into an oxaziradinium salt which can act as an oxygen donor (i.e. a bleaching species) and which is converted back into the imine quat. The oxaziradinium ion is however unstable at high pH in the compositions described above, where it is believed to be converted into an acyl hydroxamate thereby preventing the bleaching cycle from working efficiently. As a result, compositions have been limited in pH range and it has proved difficult to formulate compositions which are effective against the more recalcitrant stains particularly hydrophobic and/or pyrolised stains.

Brief Description of the Invention

It is believed that the above-mentioned problem is overcome by the use of hydrogen peroxide, rather than an organic peracid or an inorganic peroxide, as the source of oxidising equivalents. This enables the formulation of compositions to bleach at relatively high pH's where some of the more difficult stains are soluble and hence accessible to the formulation. Other, hitherto unsuspected benefits arise from the use of hydrogen peroxide as are described below.

Accordingly, the present invention provides a bleaching composition of pH 10-14 which comprises an oxygen transfer agent and hydrogen peroxide.

Without wishing to limit the scope of the present specification by reference to some theory of operation, it is believed that the reaction of

hydrogen peroxide with the imine quat. oxygen transfer agents proceeds through a different route than that of the organic and inorganic peroxides mentioned above. As a consequence, the formation of acyl hydroxamate is significantly reduced. Furthermore it is believed that when hydrogen peroxide is used as the bleaching agent in the pH range indicated, a surprising improvement in the efficacy of the bleaching system occurs and it is possible to formulate peroxide based systems which have efficacy approaching or exceeding that of hypochlorite without the disadvantages associated with hypochlorite.

A further aspect of the present invention provides a method for bleaching a stained substrate which comprises the step of treating the substrate with a bleaching composition of pH 10-14 which bleaching composition comprises an oxygen transfer agent and hydrogen peroxide.

Detailed Description of the Invention

As noted above, hydrogen peroxide is an essential component of the compositions according to the present invention. As hydrogen peroxide is a reactive species, this will place some limitations on the other components which can be present. These are described in greater detail below.

Hydrogen peroxide is preferably present at a level of 0.5-10%wt on product, more preferably 1-5%wt on product. In typical embodiments of the invention the weight ratio of the hydrogen peroxide to the oxygen transfer agent falls in the range 5:1 to 20:1.

<u>Oxygen Transfer Agents</u>

Oxygen transfer agents for use in the present invention, include, but are not limited to, the imine quat. N-methyl-3.4-dihydroisoquinolinium salts. Where these salts are used, suitable counter-ions include halides, sulphate, methosulphate, sulphonate, p-toluene sulphonate and phosphate. Oxygen transfer agents which comprise a quaternary nitrogen atom are preferred.

A broad class of oxygen transfer agents suitable for use in embodiments of the present invention are compounds comprising ions of the general structure:

$$(R_1)(R_2)C{=}N^+(R_3)(R_4)$$

Wherein:

R_1 and R_4 are in a *cis-* relation and are substituted or unsubstituted moieties selected from the group consisting of hydrogen, phenyl, aryl, heterocyclic ring, alkyl and cycloalkyl radicals:

R_2 is a substituted or unsubstituted moiety selected from the group consisting of hydrogen, phenyl, aryl, heterocyclic ring, alkyl, cycloalkyl, nito, halo, cyano, alkoxy, keto, carboxylic acid and carboalkoxy groups:

R_3 is a substituted or unsubstituted moiety selected from the group consisting of hydrogen, phenyl, aryl, heterocyclic ring, alkyl, cycloalkyl, nito, halo and cyano groups:

Preferably, R_1 with R_2 and R_3 respectively together form a moiety selected from the group consisting of cycloalkyl, polycyclo, heterocyclic and aromatic ring systems.

Heterocyclic rings according to the present specification include cycloaliphatic and cycloaromatic type radicals incorporating an oxygen, sulphur and/or nitrogen atom within the ring system. Representative nitrogen heterocycles include pyridine, pyrrole, imidazole, triazole, tetrazole, morpholine, pyrrolidone, piperidene and piperazine. Suitable oxygen heterocycles include furan, tetrahydrofuran and dioxane. Sulphur heterocycles may include thiophene and tetrahydrothiophene.

The term substituted as used in relation to R_1, R_2, R_3 and R_4 includes a substituent which is nitro, halo, cyano, C1-C20 alkyl, amino, aminoalkyl, thioalkyl, sulphoalkyl, carboxyester, hydroxy, C1-C20 alkoxy, polyalkoxy, or C1-C40 quaternary di- or tri-alkyl ammonium.

Preferred oxygen transfer agents are quaternary imine salts, particularly those set forth in US patent specification 5,360,568 (Madison and Coope), more particularly the substituted or unsubstituted isoquinolinium salts, preferably the 3,4 di-hydro isoquinolinium salts and more preferably the N-methyl 3,4 di-hydro-isoquinolinium salts. N-methyl 3,4 di-hydro-isoquinolinium p-toluene sulphonate is a particularly preferred oxygen transfer agent.

Typically, the oxygen transfer agents are present of levels of 0.001-10%wt on product. Preferably, the

oxygen transfer agents are present at levels of 0.01-1%wt on product, more preferably 0.1-0.5%wt on product.

Surfactants

It is preferred that the compositions according to the invention further comprise one or more surfactant species. Surfactants can be nonionic, anionic, cationic, amphoteric or zwitterionic provided that they, and where appropriate their counter-ions, do not react substantially with the oxygen transfer agent or the hydrogen peroxide.

Suitable nonionic detergent active compounds can be broadly described as compounds produced by the condensation of alkylene oxide groups, which are hydrophilic in nature, with an organic hydrophobic compound which may be aliphatic or alkyl aromatic in nature. The length of the hydrophilic or polyoxyalkylene radical which is condensed with any particular hydrophobic group can be readily adjusted to yield a water-soluble compound having the desired degree of balance between hydrophilic and hydrophobic elements.

Particular examples include the condensation product of aliphatic alcohols having from 8 to 22 carbon atoms in either straight or branched chain configuration with ethylene oxide, such as a coconut oil ethylene oxide condensate having from 3 to 10 moles of ethylene oxide per mole of coconut alcohol; condensates of alkylphenols whose alkyl group contains from 6 to 12

carbon atoms with 3 to 10 moles of ethylene oxide per mole of alkylphenol.

The preferred alkoxylated alcohol nonionic surfactants are ethoxylated alcohols having a chain length of C9-C11 and an EO value of at least 3 but less than 10. Particularly preferred nonionic surfactants include the condensation products of C_{10} alcohols with 3-8 moles of ethylene oxide. The preferred ethoxylated alcohols have a calculated HLB of 10-16. An example of a suitable surfactant is 'IMBENTIN 91-35 OFA' (TM, ex. Kolb AG) a C_{9-11} alcohol with five moles of ethoxylation.

Alternative surfactants include amine oxides, amines and/or ethoxylates thereof. Amine oxides with a carbon chain length of C12-C14 are particularly preferred.

When present, the amount of nonionic detergent active to be employed in the composition of the invention will generally be from 0.01 to 30%wt, preferably from 0.1 to 20%wt, and most preferably from 3 to 10%wt for non-concentrated products. Concentrated products will have 10-20%wt nonionic surfactant present, whereas dilute products suitable for spraying will have 0.1-5%wt nonionic surfactant present.

<u>pH</u>

As noted above the pH of compositions according to the present invention falls in the range 10-14. pH of compositions is preferably 10-12, more preferably 10-11. At these higher pH's we have found that the composition penetrates more readily into the soils.

As is noted in the illustrative examples given below, the use of oxygen transfer agents at high pH is contra-indicated by their tendency to increase the colour of a stain rather than reduce it.

Minors

Minor components of compositions according to the present invention include those typically present in cleaning compositions.

In compositions which contain hydrogen peroxide it is useful to include a metal ion complexing agent to retard decomposition of the peroxide by any metal ions which may be present as contaminants or such as are introduced during processing. Again, these components should be selected such that they do not react do not react substantially with the oxygen transfer agent or the hydrogen peroxide.

Preferably, cleaning and/or disinfecting compositions according to the invention will further comprise metal ion sequestrants such as ethylene-diamine-tetra-acetates, amino-polyphosphonates (such as those in the DEQUEST (TM) range) and phosphates and a wide variety of other poly-functional organic acids and salts, can also optionally be employed. Preferred metal ion sequesterants are selected from dipicolinic acid, ethylene diamine tetra acetic acid (EDTA) and its salts, hydroxy-ethylidene diphosphonic acid (Dequest 2010, RTM), ethylene diamine tetra (methylene phosphonic acid) (Dequest 2040, RTM), diethylene triamine penta(methylene phosphonic acid) (Dequest 2060, RTM), amino tri(methylene phosphonic acid)

(Dequest 2000, RTM). The phosphonic acid derivatives are particularly preferred. It is preferred that the level of phosphonic acid derivative metal ion complexing agent should fall into the range 0.05-5%.

Preferably, cleaning and/or disinfecting compositions according to the invention will further comprise at least 1% of a solvent of the form R_1-O-(EO)$_m$-(PO)$_n$-R_2, wherein R_1 and R_2 are independently C2-6 alkyl or H, but not both hydrogen, m and n are independently 0-5. More preferably, the solvent is selected from the group comprising di-ethylene glycol mono n-butyl ether, mono-ethylene glycol mono n-butyl ether, propylene glycol n-butyl ether, isopropanol, ethanol, butanol and mixtures thereof. Typically, the level of solvent in cleaning and disinfecting compositions is 1-10%, with a solvent: nonionic ratio of 1:3-3:1 being particularly preferred.

Where compositions according to the present invention are liquids, they can be water-thin or thickened. Thickened compositions are advantageous in that they cling to sloping surfaces and find particular utility in toilet cleaners. Slight thickening of the composition is desirable for applications in which the composition is sprayed, so as to reduce the extent to which small droplets are produced which might otherwise cause respiratory irritation to the user. Suitable thickening agents include amine oxide and soap and systems based on nonionic surfactants.

Compositions according to the invention can also contain, in addition to the ingredients already mentioned, various other optional ingredients such as, colourants, optical brighteners, soil suspending

agents, detersive enzymes, gel-control agents, freeze-thaw stabilisers, further bactericides, perfumes and opacifiers .

A particularly preferred compositions according to the present invention comprises a bleaching composition having a pH of 10-12, said composition being an aqueous liquid and comprising:

a) hydrogen peroxide at a level of 0.5-10%wt on product,

b) 0.001-10%wt on product of an isoquinolinium salt,

c) 0.01 to 30%wt on product of at least one nonionic surfactant, and,

d) optional minors selected from the group consisting of metal ion sequestering agents, solvents and perfumes.

<u>Product form</u>

Products according to the present invention are generally liquids and preferably aqueous. However, other product forms including pastes and solids are also envisaged.

As will be appreciated, the product form is largely determined by the end use and consequently liquids are generally suitable for use as hard surface cleaners, including cleaners for industrial, institutional and domestic cleaning and/or disinfection of hard surfaces

including metal, plastics materials or other polymers, ceramic, and glass surfaces.

It is envisaged the method of the present invention can be applied in the cleaning of surfaces used for the preparation of food and beverages (e.g. worktops, conveyor systems and utensils) or other industrial, institutional and domestic surfaces such as sanitary ware, industrial, institutional and domestic fluid supply applications, for disinfection of medical, surgical or dental apparatus, equipment, facilities or supplies, catheters, contact lens', surgical dressings or surgical instruments, in horticultural applications, e.g. for sterilising the surfaces of greenhouses, for soft surfaces including fabrics (including in dressings, wipes and cloths), and non-living materials of biological origin (such as wood). Solid product forms are suitable for use as toilet and urinal blocks and other uses where slow or delayed release of the components is required.

In order that the present invention may be further understood it will be described hereinafter by reference to illustrative and non-limiting examples and comparisons.

EXAMPLES

The following examples were performed using model kitchen soils and a soiling procedure as described below. The soils were chosen to have recalcitrant stains, which would be difficult to bleach due to the hydrophobic or pyrolised nature of the stain.

Example 1: *Curcumin/oil stain on formica (TM).*

Soil preparation

Flat tiles, measuring 4" x 4", are cut from white Formica sheeting and their surfaces thoroughly cleaned using a commercially available liquid abrasive cleaner, 'Jif' (TM). After rinsing with demineralised water, the tiles are allowed to dry at room temperature.

The curcumin/oil stain is prepared by mixing 19 g of vegetable oil and 180 g of ethanol and then adding 1 g of pure curcumin (a pigment found in curry powder). After thorough stirring, the resulting solution is sprayed onto the tiles using an airbrush propellant canister so as to give a uniform surface coverage. The tiles are left to dry for a minimum of 10 minutes, during which time the ethanol evaporates leaving a bright yellow, slightly sticky, oily stain, which cannot be removed by wiping or rinsing with water. Curcumin is susceptible to photo-oxidation and stained tiles should not be stored for periods exceeding 2 hours before use.

Preparation of Bleach or Surfactant Solutions

Experiments were performed with hydrogen peroxide, PAP (peroxy-adipoyl-phthalimide), peroxymonosulphate and sodium hypochlorite (a well known inorganic bleaching agent).

Bleach solutions are prepared by dissolving the peroxide co-oxidant in demineralised water and, where

necessary, adding the oxygen transfer agent. Sodium hydroxide solution (5 mol dm^{-3}) is added dropwise to adjust the pH to the desired value, as determined using a pH meter. Further demineralised water is added to the solution to give the desired final volume.

In the examples described the oxygen transfer agent was N-methyl 3,4 di-hydro isoquinolinium p-toluene sulphonate. The preparation of this material is described in US 5360569 and US 5360568 which are incorporated herein by reference. The material is referred to below as the 'Imine Quat'.

Hydrogen peroxide solutions are prepared to achieve a final concentration of 3 w/w % (0.88 mol dm^{-3}) and used in conjunction with a 1% molar equivalency of the Imine Quat catalyst (0.0088 mol dm^{-3}, 0.30 w/w %). Solutions of potassium Caroate (TM: 6 w/w%, equivalent to 3 w/w%, 0.2 mol dm^{-3} peroxomonosulphate) and PAP (6-[N-phthalimido]-perhexanoic acid: 2 w/w%, 0.012 mol dm^{-3}) were examined in combination with the same level of Imine Quat. The potassium peroxymonosulphate system was examined at pH 8.5 (but higher pH values were used for hydrogen peroxide (which has a higher pK_a) and PAP (which is relatively insoluble at lower alkalinities). Addition of a wetting agent (1% butyl digol (TM): diethylene glycol mono n-butyl ether) further increases the PAP solubility.

The bleach systems are compared with the detergency obtained using a C_{9-11} EO_5 nonionic surfactant, Imbentin 91-35 OFA (TM) in the formulations listed in TABLE 1 below. In some instances a solvent 'Butyl Digol'

(TM), di-ethylene glycol mono-n-butyl ether, was added or used for comparison.

Soil removal experiments

Examples were performed at room temperature. A glass ring, of diameter 50 mm and height 15 mm, is placed over the centre of the stained tile and 5 cm^3 of the aqueous bleach or surfactant solution is pipetted within the annulus of the ring. The solution is allowed to remain in contact with the stained tile surface for 30 seconds, after which the glass ring is removed and the solution poured away. The tile is immediately rinsed with demineralised water for a further 30 seconds and then allowed to dry. Each solution is used to treat two tiles.

The extent of stain removal is assessed visually by a panel of at least 15 people, using a standard scale. Tiles are graded on an integer scale ranging from 0 to 5, where 0 denotes no visible soil removal and 5 corresponds to total removal. A minimum of two stained tiles are treated with each bleach solution and mean scores for each system are calculated by averaging the scores from both tiles.

Results are shown in TABLE 1 below. From the results presented in TABLE 1, it can be seen that a significant improvement as regards hydrogen peroxide bleaching is obtained in the presence of the Imine Quat at both pH 10 and pH 10.5. A similar increase is not seen for either the organic or inorganic peroxy acid.

Comparing the results with conventional cleaning/bleaching systems. It can be seen that use of an oxygen transfer agent together with hydrogen peroxide provides results which are very favourably comparable with hypochlorite, and significantly better than alkali and surfactant based systems.

TABLE 1

System	Without Imine Quat.	With 0.3% Imine Quat
3% Hydrogen Peroxide at pH 10.0	0.1	1.3
3% Hydrogen Peroxide at pH 10.5	1.3	3.1
2% PAP/1% Butyl Digol at pH 10.0	0.1	0.3
3% K-monoperoxysulphate at pH 8.5	0	0
1% NaOCl at pH 10	2.9	-
1% NaOCl at pH 10.5	3.8	-
Alkali at pH 10.0	0.2	-
Alkali at pH 10.5	1.6	colour of stain increased
0.1% Imbentin at pH 10.0	1.0	-
0.1% Imbentin at pH 10.5	1.5	-

Example 2: *Baked fat/flour on enamel*

Soil preparation

Oleic acid (1 g), stearic acid (1 g) and Friol (TM) Italian Oil (38 g) are mixed in a metal beaker and directly heated, using a hotplate, to a temperature of 60°C, so that the mixture liquifies. Demineralised water (100 g) is boiled and allowed to cool to 60°C before mixing with Italian flour (40 g) to make a thick paste.

The organic acid-oil mixture and the flour paste are placed in a liquidiser jug and demineralised water (280 g) added. The fat-flour mixture is blended for 5 seconds, allowed to stand for 10 seconds and then blended for a further 5 seconds. The contents of the liquidiser are then transferred to a glass beaker and gently warmed by direct heating over a hot-plate. The mixture is allowed to simmer for five minutes with constant agitation from an overhead stirrer. The mixture must not be allowed to stick to the beaker or excessive cross-linking will occur, resulting in a soil that is overly resistant to removal. The mix is then transferred to a polythene beaker and allowed to cool before use.

Soil application

White enamel tiles (100 mm x 100 mm) are cleaned using a commercially available liquid abrasive cleaner ('Jif' [TM]), rinsed in demineralised water and allowed to dry. The tiles are then coated with a thin (*c.a.* 0.5 mm) layer of the fat/flour mix using a

screen printing technique. A flexible rubber paddle is used to spread the mix onto the tile surface, through a thin plastic mesh, taking care to achieve a uniformly thin coverage. The soiled tiles are allowed to stand overnight in the open air, acquiring a uniform matt finish. The tiles are baked on the middle shelf of an oven at 190°C for one hour, developing a light brown colouration, and allowed to cool for 2 hours before cleaning. As there is expected to be variation between batches of these tiles soiled and subsequently pyrolised, it is important that comparisons are performed with tiles taken from the same batch.

<u>Preparation of Bleach and Surfactant Solutions</u>

Solutions are prepared as described for the curcumin-oil soil removal experiments described above with reference to TABLE 1 using the formulations listed in TABLE 2 below. Detergency effects have been studied using Neodol 91-5 (TM) nonionic surfactant, a commercially available, slightly less pure, version of the Imbentin 91-35 OFA (TM) surfactant used in the curcumin/oil experiments above. Admox 10 (TM) is a C_{10} amine oxide surfactant.

Peracetic acid is used at a concentration equal to that of the HOO^- active oxidising species present in the 3% hydrogen peroxide solution at the same pH (10.0).

Soil removal experiments

Soil removal is carried out using a standard Wool Industries Research Association Abrasion Tester (WIRA: TM) apparatus. Two soiled tiles are cleaned simultaneously with the same solution, to provide duplicate results. The bleach or surfactant solution (20 cm^3) is poured onto the surface of the tile, and rubbed using a cleaning head covered with two layers of clean 'J'-cloth (TM) material. Each tile is cleaned using 51 strokes of the head. The tiles are then immediately removed from the apparatus, rinsed under running water and patted dry using paper tissues.

As noted above, although the colouration and ease of soil removal is uniform for tiles coated with a specific fat-flour mixture, there is some variability between different batches of soil. Consequently, the results shown below in TABLE 2 are grouped in sets (TABLE 2a, 2b and 2c), each carried out using a different batch of fat-flour soiled tiles. Experiments using Jif (TM) liquid abrasive cleaner and Domestos Multi-Surface Cleaner (TM), a commercial hypochlorite hard surface cleaning product, are included in each series of runs to provide reference standards. The extent of soil removal is assessed visually by a panel of at least 5 people, using a standard scale. Tiles are graded on a scale ranging from 0 to 10, and panellists award integer or half-integer scores to each tile. A score of 0 denotes no visible soil removal and 10 corresponds to total soil removal. Mean scores for each soil removal system are calculated by averaging scores from both replicates.

Comparing the results with conventional cleaning/bleaching systems, it can be seen that use of an oxygen transfer agent together with hydrogen peroxide provides results which are very favourably comparable with hypochlorite and commercial products based on hypochlorite, and which are significantly better than alkali and surfactant based systems. It can be seen from table 2d that while the imine quat shows a reduced effect in the presence of surfactant, the improvement over systems which do not contain the imine quat. is still measurable.

TABLE 2a

System	Without Imine Quat.	With 0.3% Imine Quat
3% Hydrogen Peroxide at pH 10.5	8.5	9.0
3% K-monoperoxysulphate at pH 8.5	5.6	5.6
Domestos Multi Surface Cleaner at pH 11.5	10	-
JIF at pH 11.0	5.8	-
Alkali at pH 10.5	6.4	-
0.1% Neodol at pH 10.5	3.5	-

TABLE 2b

System	Without Imine Quat.	With 0.3% Imine Quat.
3% Hydrogen Peroxide at pH 10.0	3.9	4.9
0.12% peracetic acid at pH 10.0	2.9	3.8
Domestos Multi Surface Cleaner at pH 11.5	9.1	-
JIF at pH 11.0	3.6	-

TABLE 2c

System	Without Imine Quat.	With 0.3% Imine Quat
3% Hydrogen Peroxide at pH 10.0	7.2	9.1
Domestos Multi Surface Cleaner at pH 11.5	10	-
3% NaOCl at pH 10.0	8.1	-

TABLE 2d

System	Without Imine Quat.	With 0.3% Imine Quat
3% Hydrogen Peroxide at pH 10.0	7.5	8.0
3% Hydrogen Peroxide & 0.1% Admox 10 at pH 10.0	7.3	7.9
Domestos Multi Surface Cleaner at pH 11.5	9.4	-
JIF at pH 11.0	4.3	-

CLAIMS

1. A bleaching composition of pH 10-14 which comprises an oxygen transfer agent and hydrogen peroxide.

2. A bleaching composition according to claim 1 wherein hydrogen peroxide is present at a level of 0.5-10%wt on product.

3. A bleaching composition according to claim 1 wherein the weight ratio of the hydrogen peroxide to the oxygen transfer agent falls in the range 5:1 to 20:1.

4. A bleaching composition according to claim 1 wherein the oxygen transfer agent is a compound comprising ions of the general structure:

$$(R_1)(R_2)C{=}N^+(R_3)(R_4)$$

wherein:

R_1 and R_4 are in a *cis*- relation and are substituted or unsubstituted radicals selected from the group consisting of hydrogen, phenyl, aryl, heterocyclic ring, alkyl and cycloalkyl radicals:

R_2 is a substituted or unsubstituted radical selected from the group consisting of hydrogen, phenyl, aryl, heterocyclic ring, alkyl,

cycloalkyl, nito, halo, cyano, alkoxy, keto, carboxylic acid and carboalkoxy groups; and,

R_3 is a substituted or unsubstituted radical selected from the group consisting of hydrogen, phenyl, aryl, heterocyclic ring, alkyl, cycloalkyl, nito, halo and cyano groups:

5. A bleaching composition according to claim 4 wherein the oxygen transfer agent is a substituted or unsubstituted isoquinolinium salt.

6. A bleaching composition according to claim 1 having a pH of 10-12, said composition being an aqueous liquid and comprising:

a) hydrogen peroxide at a level of 0.5-10%wt on product,

b) 0.001-10%wt on product of an isoquinolinium salt,

c) 0.01 to 30%wt on product of at least one nonionic surfactant, and,

d) optional minors selected from the group consisting of metal ion sequestering agents, solvents and perfumes.

7. A method for bleaching a stained substrate which comprises the step of treating the substrate with a bleaching composition as defined in any one of claims 1-6.

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